BENTHIC ECOLOGY OF WHANGAPE HARBOUR, NORTHLAND

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Abstract. Whangape is a small Y-shaped harbour which opens to the Tasman Sea on the west coast of Northland through a narrow, 4 m deep and 4 km long gorge. The biota of the harbour floor sediments has a low diversity and is more like that of a large estuary than a northern harbour. Pipi (*Paphies australis*) and cockles (*Austrovenus stutchburyi*) are the dominant benthic organisms. Live pipi are largely subtidal and occur in the cleaner, coarser sediments of the entrance channel (up to 50 per litre) and Rotokakahi arm. Live cockle are intertidal and subtidal and mostly occur in muddy sediment of Awaroa arm, the central basin and lower Rotokakahi arm. The most diverse fauna occurs in the central basin just inside the entrance channel. Medium sand in the centre of the basin is dominated by pipi with associated hermit crabs, whelks (*Cominella glandiformis* and *C. maculosa*), chitons (*Chiton glaucus*), limpets (*Notoacmea helmsi*) and anemones (*Anthopleura aureoradiata*). Fine sandy mud to the sides of the basin is dominated by nut shells (*Nucula hartvigiana*), wedge shells (*Tellina liliana*) and cockles, with associated bivalves (*Notirus reflexus*), saucer limpets (*Sigapatella novaezelandiae*) and polychaetes (*Glycera tesselata, Owenia fusiformis* and *Lumbrinereis aotearoae*).

PREVIOUS WORK

There have been several previous studies on the ecological distribution of the bottom-dwelling biota of harbours and estuaries around New Zealand. Studies in northern New Zealand have mainly dealt with the larger harbours - Manukau Harbour (Grange 1979, 1982; Henriques 1977) and Waitemata Harbour (Powell 1937) - although Grace (1966) and Brook *et al.* (1981) documented the subtidal fauna of the smaller Whangateau and Tutukaka Harbours on the east coast and Hayward & Hollis (1993) described the fauna of the small estuary at the mouth of Waimamaku estuary, 30 km south of Whangape on the west coast.

LOCATION AND DESCRIPTION

Whangape Harbour (latitude 36° 20', longitude 173° 15') is located on the west coast of Northland, between Hokianga and Herekino harbours (Fig. 1). Whangape is a relatively small "Y-shaped" harbour formed by the confluence of the estuaries or arms of two rivers. The harbour can be divided into four parts: the entrance channel, a shallow central basin and the two estuaries.

(a) Entrance channel

The narrow entrance channel to the harbour is a former river gorge, with its sides rising steeply on both sides to 250-300 m above sea level. The entrance channel is almost 4 km long,

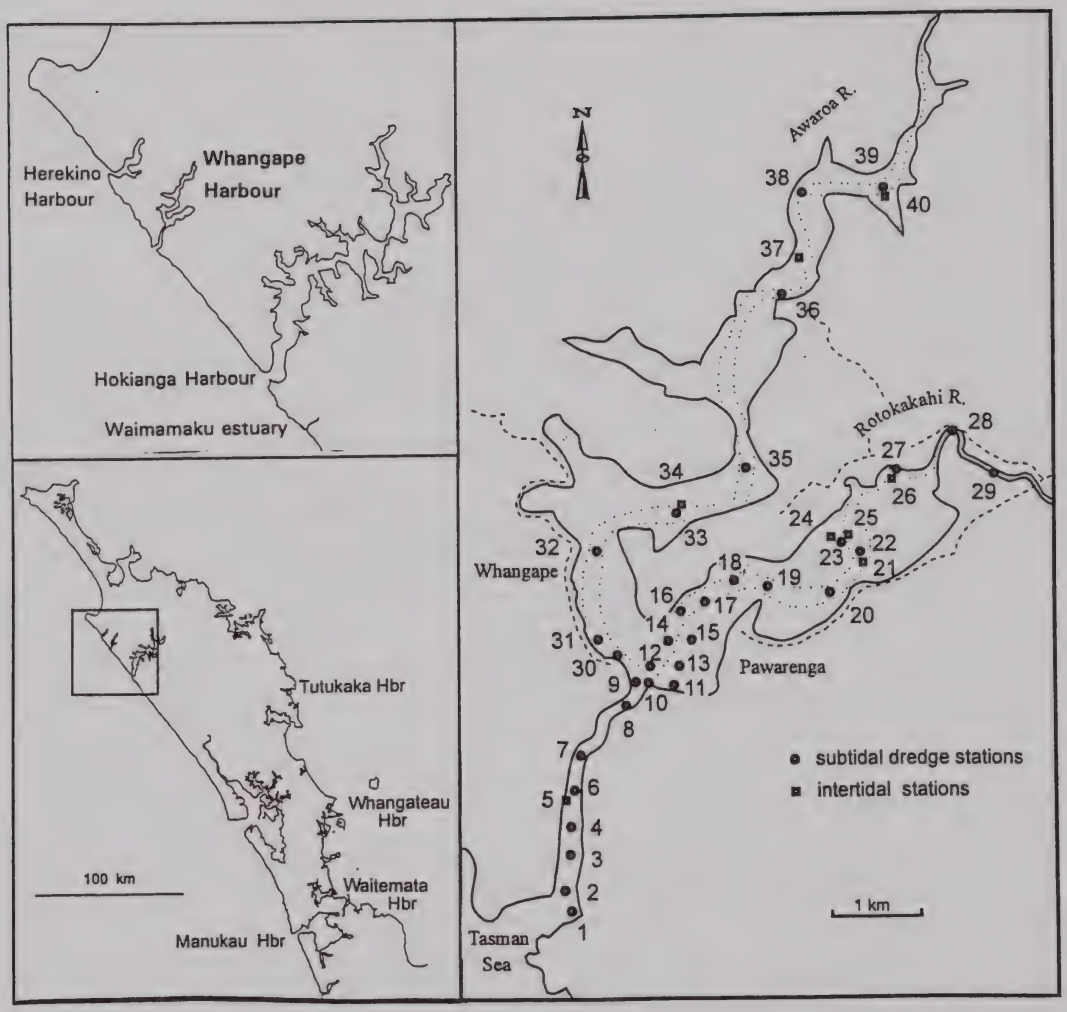

Fig. 1. Location of benthos sampling stations in Whangape Harbour, on the west coast of Northland.

straight for most of its length with a slight dogleg towards the mouth. It is 120 m wide at the landward end, slowly widening to 300 m at its mouth where it enters the Tasman Sea. Both sides of the entrance channel are lined with narrow gravel beaches or rocky coast. The channel has a near uniform depth of 3.5-4 m for most of its length, deepening only slightly to 5 m as it nears the central basin.

(b) Shallow central basin

The two estuaries meet in a broad, shallow central basin between Whangape and Pawarenga. At high tide this basin is approximately 1 by 2 km. At low tide, large areas are exposed as tidal sand and mud flats, cut by 2-5 m deep channels linking the estuaries with the narrow harbour entrance channel.

(c) Two estuaries

The Awaroa River estuary is the northern and larger of the two, extending 11 km inland from its confluence with the smaller Rotokakahi River estuary, which extends 6 km inland. The subtidal channels of both estuaries are 1-3 m deep. The Awaroa estuary channel is 60-120 m across and is lined for most of its length by intertidal mangrove forest up to 500 m wide. The Rotokakahi estuary channel is 10-100 m wide and is lined by a combination of mangrove forest, salt marsh, and in its upper reaches, by eroding alluvial banks.

FIELD METHODS

This survey was undertaken by BWH and CJH with the assistance of Michael Eagle, Clare Ward and Fred Brook on 11-12 April 1992. Samples were collected using a small, 4 litre capacity bucket dredge, hand-hauled from a 4 m aluminium dinghy powered by a 7 horse power outboard motor. The sediment was sampled to a depth of 50-100 mm. The sediment grain size was recorded and a 200 ml split was kept; the remainder was washed over a 2 mm sieve to remove mud and sand and then all live organisms were picked out, identified, counted and returned to the sea. Where the identification was uncertain, specimens were preserved and brought back to the museum for study. Voucher specimens of most taxa are held in the marine collections of the Auckland Institute and Museum.

SEDIMENTS (Fig. 2)

The floor of Whangape Harbour has a wide range of sediment types.

(a) Entrance channel

The outer 2 km of the narrow entrance channel is carpeted in well sorted, clean medium to coarse sand that has been swept in from the exposed seafloor outside the harbour mouth. The inner 2 km of the entrance channel is paved with shell gravel composed almost entirely of live and dead pipi shells. The strong tidal currents that sweep in and out of the harbour do not allow any sand or mud to settle on the floor of this 4 m deep channel.

(b) Shallow central basin

Where the harbour broadens out, the floor is covered in fine sandy mud with a wedge of clean medium sand extending into the harbour basin immediately opposite the entrance channel.

(c) Two estuaries

The extensive areas of intertidal mangrove forest and salt marsh along the margins of both arms have a silt or clay substrate. The subtidal (0.5-3 m deep) channels of the two arms have contrasting sediment types. The larger Awaroa River channel is floored with fine sandy mud which becomes pebbly mud near its head. The lower reaches of the smaller Rotokakahi River channel are floored with pebbly medium sand which grades upstream into fluvial pebbly coarse sand.

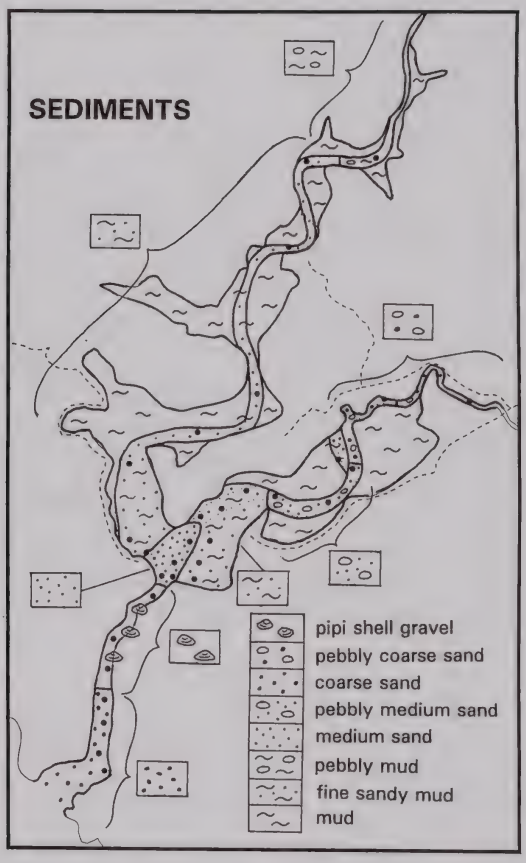

Fig. 2. Distribution of sediment types in Whangape Harbour. Sediment patterns in boxes summarise the geographic trends seen in the subtidal and intertidal sediments.

ECOLOGIC DISTRIBUTION PATTERNS OF BENTHIC ORGANISMS

(a) Entrance channel

The clean medium to coarse sand just inside the harbour mouth (stns. 1, 2) is home to numerous, albeit patchily distributed, sand dollars (*Fellaster zelandica*; Fig. 3) and very little else. The sand and shell gravel bottom of the remaining 3 km of the channel (stns. 4-8) is largely inhabited by a thriving population of pipi (*Paphies australis*; Fig. 3). Commonly associated are three species of the scavenging gastropod *Cominella* (*C. adspersa, C. glandiformis, C. maculosa*) and two species of hermit crab (*Paguristes pilosus* and *Pagurus novaezelandiae*; Fig. 4). Less common inhabitants of the pipi shell gravel of the entrance channel are several chitons, the gastropods *Xymene ambiguus* and *X. plebeius,* the Pacific oyster (*Crassostrea gigas*), the swimming crab (*Liocarcinus corrugatus*) and three polychaete worms (*Lepidonotus polychromus, Pherusa parmata* and *Streblosoma* ?*gracile*). The nut shell (*Nucula hartvigiana*) is common in the slightly deeper, sandier landward end of the channel approaching the central basin (Fig. 3).

(b) Shallow central basin

The central basin contains a patchy mixture of benthic organisms which provide the most diverse fauna of the harbour. The wedge of medium sand that extends into the basin from the entrance channel is dominated by pipi (Fig. 3) with associated hermit crabs and whelks (*Cominella glandiformis* and *C. maculosa*). Also present on the pipi shells are occasional chitons (*Chiton glaucus*), limpets (*Notoacmea helmsi*) and anemones (*Anthopleura aureoradiata*). Other less common inhabitants are gastropods (*Diloma subrostrata* and *Xymene plebeius*), bivalves (*Felaniella zelandica*), crabs (*Cyclograpsus lavauxi*), clingfish (*Trachelochismus pinnulatus*) and polychaete worms (*Glycera americana*). The fine sandy mud substrate of the remainder of the central basin is dominated by combinations of three bivalves - nut shells, wedge shells (*Tellina liliana*) and cockles (*Austrovenus stutchburyi*; Fig. 3). Also present are rare specimens of the bivalve *Notirus refluxus,* saucer limpet (*Sigapatella novaezelandiae*) and polychaete worms (*Glycera tesselata, Owenia fusiformis* and *Lumbrineris aotearoae*).

(c) Two estuaries

The intertidal mud of the mangrove forests and salt marsh that border both estuaries is largely inhabited by the mud crab (*Helice crassa*) and the mud snail (*Amphibola crenata*). The fine sandy mud of the subtidal channel of Awaroa estuary is dominated by rich populations of cockles (Fig. 3). Also present in the lower reaches are occasional specimens of the bivalves *Mactra ovata* and nut shell, the crabs *Cyclograpsus lavauxi* and *Liocarcinus corrugatus* and shrimp *Pontophilus chiltoni*. The pebbly sand of the subtidal channel of Rotokakahi estuary is dominated by rich pipi populations. The only other live organisms recorded in these sediments are small numbers of cockles, which are restricted to the lower reaches.

DISTRIBUTION PATTERNS OF INDIVIDUAL SPECIES

The dominant mollusc species in the harbour all appear to have independent distribution patterns that overlap in part.

Pipi, *Paphies australis* (Fig. 3)

Live pipi are largely subtidal in Whangape Harbour and confined to the cleaner, coarser sediments of the entrance channel and Rotokakahi estuary channel. The species tolerates a wide range of salinity, from near normal in the entrance channel to highly brackish near the head of the estuary. At the time of the survey most of the pipi sampled were small. Those in Rotokakahi estuary were mostly 6-15 mm long, whereas those in the entrance channel were mostly 15-35 mm long. Two peaks of abundance were identified: one where the entrance channel meets the central basin, where pipi reached densities of up to 50 per litre; the second in the mid reaches of the estuary channel with a similar density.

Cockle, *Austrovenus stutchburyi* (Fig. 3)

Live cockles are both intertidal and subtidal and mostly confined to finer, muddy sediments of Awaroa estuary, the central basin and lower Rotokakahi estuary. Cockles at low densities co-occur with pipi in the lower reaches of Rotokakahi estuary. Cockles appear to

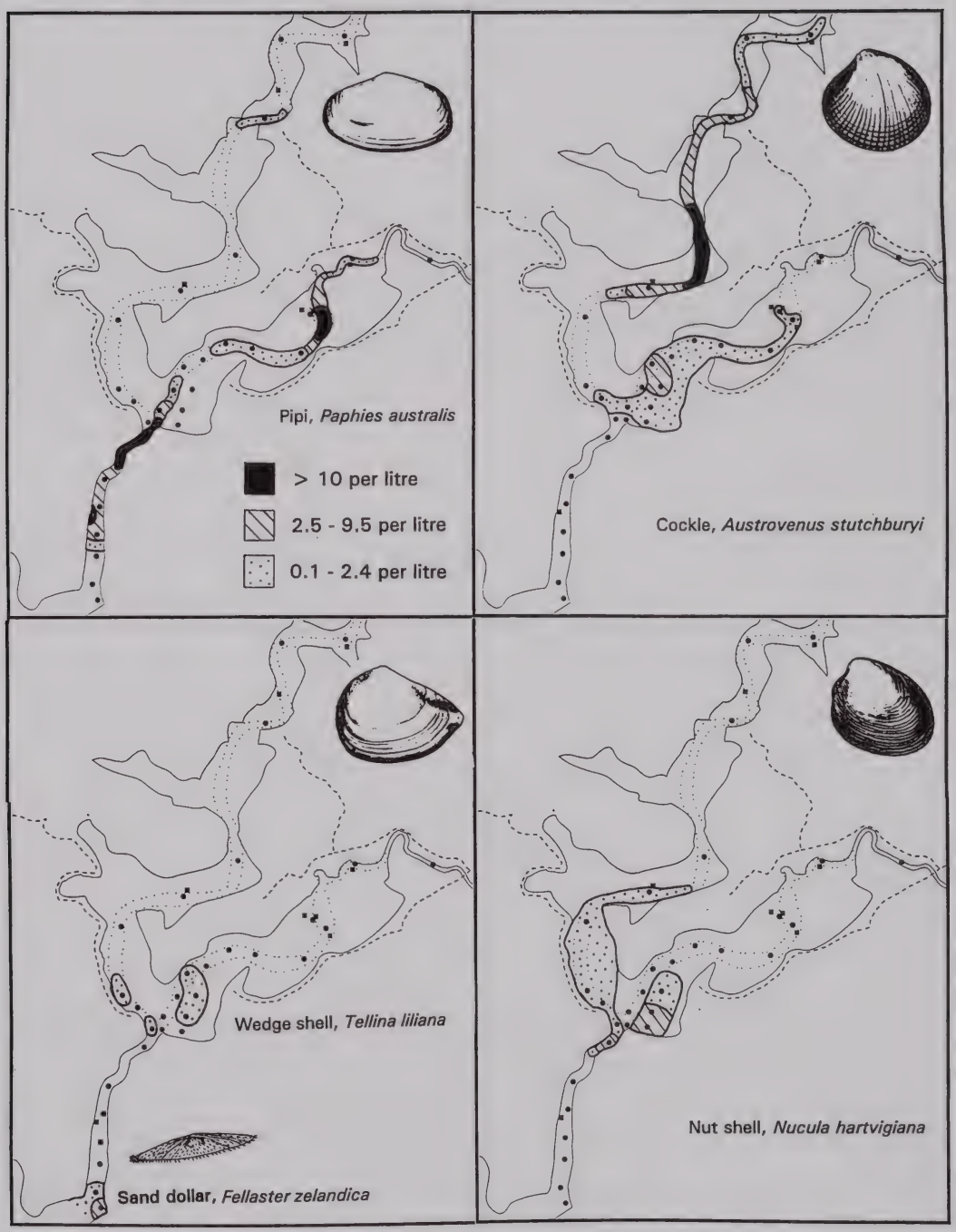

Fig. 3. Contoured abundance and distribution maps of the common molluscs and echinoderms in Whangape Harbour.

tolerate a similar wide range of salinity to pipi. Two peaks of abundance were identified: the greater density (10 per litre) is in the middle reaches of Awaroa estuary; the second peak (3 per litre) is in the low tidal fine sandy mud of the central basin.

Wedge shell, *Tellina liliana* (Fig. 3)

Live wedge shells live at low densities both intertidally and subtidally in fine sandy mud in the central basin. None were found up either estuary nor in the entrance channel. They overlap with the seaward part of the range of cockles.

Nut shell, *Nucula hartvigiana* (Fig. 3)

Live nut shells live intertidally and subtidally in both muddy and coarse sand substrates in and close to the central basin. The greatest abundance is 5 per litre in low tidal sandy mud (stn. 11). Nut shell distribution is similar to wedge shell, except that it extends seaward into coarse sediment in the entrance channel.

Whelks, *Cominella* spp. (Fig. 4)

The three species of whelks in Whangape Harbour have overlapping ranges and occur in the subtidal pipi gravel and sand of the entrance channel and central basin. *C. glandiformis* is the most abundant and has the widest recorded distribution.

Hermit crabs, *Pagurus* and *Paguristes* (Fig. 4)

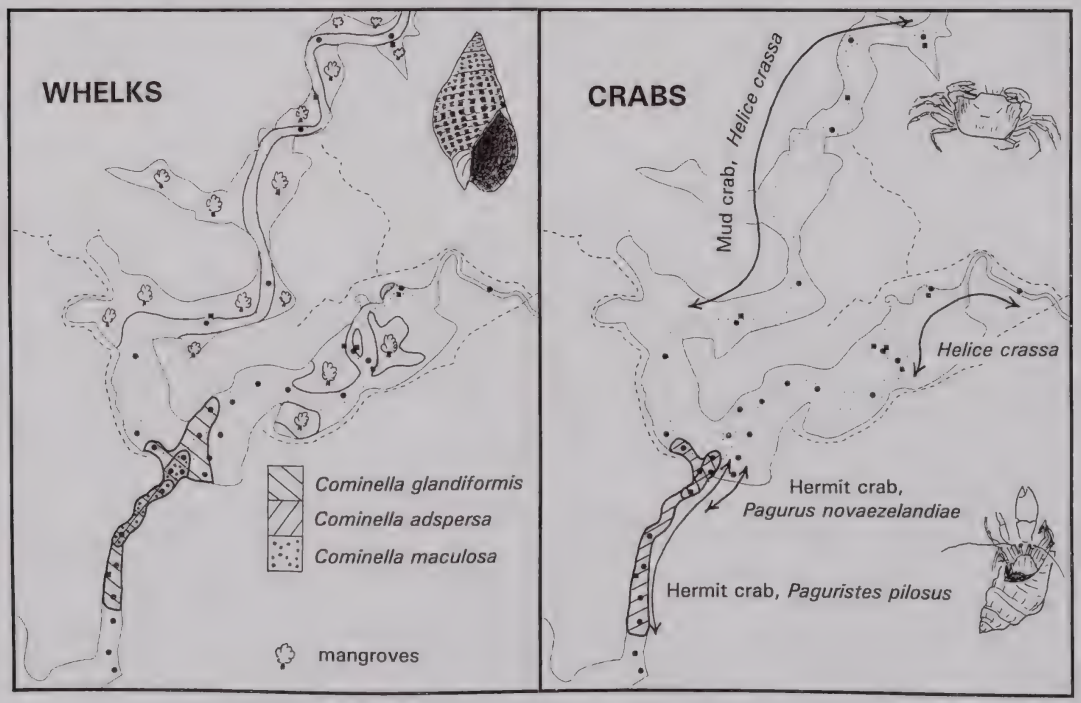

Fig. 4. Distribution in Whangape Harbour of whelks and crabs.

Pagurus novaezelandiae and *Paguristes pilosus* occur on pipi shell gravel and medium sand in the current-swept entrance channel. *Pagurus novaezelandiae* appears to prefer finer substrates in slightly less current swept conditions, at intertidal and shallow subtidal depths. *Paguristes pilosus* occurs commonly in shallow subtidal depths of 1-5 m. This is in contrast to its recorded range in Otago waters of 10-85 m (Schembri & McLay 1983). Studies around northern New Zealand show it to be common at shallow subtidal depths in many places (pers. obs.).

DISCUSSION

INTRODUCED SPECIES

The only introduced species recorded in Whangape is the Pacific oyster, which was found only in low numbers. In contrast to Waimamaku River estuary, a few kilometres to the south, Pacific oyster was not found living in the subtidal channels of either of Whangape Harbour's estuaries (Hayward & Hollis 1993). Harbours on the east coast of Northland and Auckland have been invaded by a number of introduced species in the last few decades. Exotic bivalves that have the potential to thrive in Whangape include the Asian mussel (*Musculista senhousia*), the thin-shelled *Theora lubrica* and *Limaria orientalis.*

COMPARISONS WITH OTHER NORTHERN HARBOURS AND ESTUARIES

Whangape Harbour appears to have the lowest diversity of animal life living in and on the bottom sediments of all the previously studied harbours, large and small, in northern New Zealand. Many species common elsewhere are absent or insufficiently abundant to have been sampled during this study. These absent species include gastropods (*Amalda* spp., *Maoricolpus roseus, Zeacolpus pagoda, Zegalerus tenuis*), bivalves (*Dosinia* spp., *Gari* spp., *Myadora* spp., *Ruditapes largillierti*), heart urchins (*Echinocardium cordatum*), crabs (*Halicarcinus varius, Hemigrapsus crenulatus, Macrophthalmus hirtipes, Petrolisthes* spp.) and worms (*Axiothella* spp., *Aglaophamus macrura, Pectinaria australis*).

The abundance of the sand dollars and hermit crabs *Paguristes pilosus* and *Pagurus novaezelandiae* on the current-swept floor of Whangape entrance channel has parallels with the low diversity *Pagurus-Fellaster* community inhabiting the well-sorted fine sand in the Manukau Harbour entrance channel (Grange 1979). The dominance of pipi living in a pipi shell hardground throughout the length of Whangape's narrow, 4 m deep entrance channel is a feature also observed in the narrow current-swept, subtidal entrance channel to Whangateau Harbour (Grace 1966). Elsewhere pipi form dense intertidal and low tidal beds in the mouths of many tidal estuaries around New Zealand (pers. obs).

The most diverse fauna in Whangape Harbour occurs in the shallow central basin. The dominant organisms (*Cominella glandiformis, C. maculosa, Tellina liliana, Nucula hartvigiana, Austrovenus stutchburyi, Paphies australis, Paguristes pilosus, Anthopleura aureoradiata, Glycera* sp., *Owenia fusiformis*) are all common elements of the shallow subtidal fauna of the channels and basins in inlets around the sheltered, somewhat brackish, upper reaches of Manukau, Waitemata and Tutukaka harbours (Grange 1982, Brook *et al.* 1981), although the diversity at Whangape is considerably less than in these larger harbours.

Cockles and pipi occur as community dominants in close association in many brackish estuaries and harbour inlets throughout New Zealand (e.g. Grange 1982, Hayward & Hollis 1993). Their distribution patterns suggest that both have similar salinity requirements, although cockles show a greater tolerance of muddy conditions. Whangape Harbour provides one of the clearest examples so far studied, of the influence of substrate on the distribution of these cockles and pipi. Cockles are dominant in the finer sandy mud and pipi in the cleaner pebbly sand and shell gravel.

In summary, the fauna of Whangape Harbour is more typical of a large estuary than a harbour. Only the outer part of the entrance channel with its abundant sand dollars, has features more usually found in harbours.

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APPENDIX 1. Whangape Harbour sample station data with Auckland Museum Marine Departments' sample catalogue numbers. LT = low tide, MT = mid tide, HT = high tide.

Stn.	Cat.No.	Depth (m)	Sediment type
1	L1293	4	medium to coarse sand
2	L1294	4	medium to coarse sand
3	L1295	4	medium sand
4	L1296	3.5	pipi shell gravel
5	L1291	LT	slightly muddy, pebbly coarse sand
6	L1292	4	pipi shell gravel
7	L1297	4	pipi shell gravel
8	L1298	5	shelly coarse sand
9	L1270	5	shelly medium sand
10	L1271	5	medium sand
11	L1272	0.5	mud
12	L1299	1.5	slightly shelly, medium to fine sand
13	L1273	0.3	muddy very fine sand
14	L1274	2	medium sand
15	L1275	LT	fine sandy mud
16	L1276	2	fine sandy mud
17	L1277	1.5	slightly muddy medium sand
18	L1278	2	muddy fine sand
19	L1279	2	slightly muddy, pebbly medium sand
20	L1280	1.5	slightly muddy, pebbly medium sand
21	L1290	MT	mud
22	L1289	0.5	pebbly, muddy fine sand
23	L1287	0.5	muddy fine sand
24	L1286	HT	slightly sandy mud
25	L1288	HT	medium sand
26	L1285	HT	muddy clay
27	L1284	0.5	coarse sand
28	L1283	3	slightly muddy, pebbly coarse sand
29	L1281	HT	pebbly coarse sand
30	L1300	2	fine sand
31	L1301	2.5	mud
32	L1302	3	slightly sandy, shelly mud
33	L1310	1.5	slightly shelly, slightly sandy mud
34	L1311	MT	mud
35	L1303	2.5	sandy mud
36	L1309	2	mud
37	L1304	MT	mud
38	L1308	0.5	fine sandy mud
39	L1307	2	pebbly mud
40	L1305	HT	clay

APPENDIX 2. Species recorded in Whangape Harbour survey stations. Number of specimens is given in brackets after the station number, p = present in non-quantitative intertidal stations.

AMPHINEURA
Chiton glaucus 8(2),12(10)
Ischnochiton maorianus 8(1)
Rhyssoplax aerea 4(1),8(5)

GASTROPODA
Amphibola crenata 24(p),25(p),26(p),34(p)
Cominella adspersa 7(2),8(1)
Cominella glandiformis 4(3),7(1),10(2),11(1),12(6),16(1),30(1)
Cominella maculosa 7(2),8(1),12(1)
Diloma subrostrata 12(9)
Notoacmea helmsi 12(3)
Potamopyrgus antipodum 26(p)
Sigapatella novaezelandiae 32(1)
Xymene ambiguus 6(1)
Xymene plebeius 8(1),10(2),12(1)

BIVALVIA
Austrovenus stutchburyi 9(1),11(2),12(1),13(9),15(18),16(23), 17(2),18(5),20(3),22(1),23(2),30(1),33(25),35(100),36(20), 38(3),39(2)
Crassostrea gigas 6(1)
Felaniella zelandica 30(1)
Mactra ovata 35(2)
Notirus reflexus 32(1)
Nucula hartvigiana 8(15),9(1),11(45),13(11),15(2),30(10),31(5), 32(5),33(5)
Paphies australis 4(15),5(50),6(8),7(30),8(120),10(150),12(15), 14(6),18(4),19(8),20(9),22(200),27(2),36(2)
Tellina liliana 9(1),13(4),15(3),16(2),31(1)

COELENTERATA
Anthopleura aureoradiata 10(5),16(1)

ANNELIDA
Glycera americana 9(1)
Glycera tesselata 32(1)
Lepidonotus polychromus 6(2)
Lumbrineris aotearoae 32(1)
Owenia fusiformis 31(2)
Pherusa parmata 6(1)
Streblosoma ?gracile 6(1)

CRUSTACEA
Cyclograpsus lavauxi 12(3),35(3)
Helice crassa 22(15),24(p),25(p),26(p),29(p),34(p),37(p),40(p)
Liocarcinus corrugatus 4(1),35(3)
Paguristes pilosus 3(2),4(5),6(1),12(2),30(4)

Pagurus novaezelandiae 8(2),12(2)
Pontophilus chiltoni 35(1)
isopod indet. 1(1)

ECHINODERMATA
Fellaster zelandica 1(20),2(1)

PISCES
Trachelochismus pinnulatus 12(2)